Perceptual control theory/Demonstrations

From BluWiki

Demonstrations of perceptual control (also via http://pctdemos.notlong.com)

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[edit]

Non-computer-based demonstrations

Most of the demonstrations initially listed in this section were taken from Cziko (1992).
[edit]

Rubber bands (also known as binders, elastics, lacker bands and

gumbands)

[edit]

Classic demos (and variations)

See The Nature of PCT (Powers)

- demonstrator as disturber, volunteer as controller
- ask volunter to keep not over specified spt
- ask audience what volunteer is doing and have subject agree or disagree
- demonstrator can cover his end of rubber band to demonstrate that volunteer is not responding to the disturbance
- demonstrator can add more disturbing rubber bands to how complex it wold be for the volunteer to know where to put his hand based on a calculated fuunction of all disturbances
- demonstrator can hide knot (or ask volunteer to close his or her eyes) to show impossibility of task without visual feedback
- demonstrator can ask volunteer to vary controlled position of knot among two or more locations to show change of reference level, or make dynamic pattern with knot, such as a circle
- demonstrates
  - closed loop system
  - change of reference level
  - controlled variable
  - symmetry of disturbance and action
  - feedback is used, not feedforward
- variations
  - demonstrator as controller (subject), volunteer as experimenter-disturber (volunteer attempts to discover what demonstrator (subject) is doing

Using two (or more) rubber bands joined by a visible knowt (see Powers, 1973, pp. 241-244).

[edit]

Using disturbances to control behavior

- subject agrees to keep knot over a reference mark
- demonstrator distrubs in such as a way so that subject puts hand in desired spot or creates a desired pattern (e.g., writes a word with a piece of chalk or penlooped inside rubber band)
- limit of control can be shown by telling the subject that he or she must pay a certain amount of money for each second he or she has hand over target spot

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Conflict

- subjects on different ends of joined, knotted rubber bands with different reference marks
- one or both subjects will usually give in to avoid breaking rubber bans

[edit]

Three rubber bands joined by a knot (from Powers, CSGnet, 1992.04.07 11:00)

- demonstrator distrubs with one or two rubber bands wile subject responds with one or two rubber bands using large, medium and small disturbances
- subject's response depends on rubber-band environment
- demonstrates how responses may be due to properties of the environment, not the subject

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Disturbances to "ballistic" behavior (Cziko)

- demonstrator attaches long and wide rubber band(s) (e.g., made from knotted strips of bicycle inner tube) to subject's writs
- subject practices an "open-loop" task such as throwing a tennis ball into a waste-paper basket or at a target on a chalk board a short distance away
- after subject demonstrates success, demonstrator(s) pulls on rubber band(s) while behavior is taking place
- subject will at least some resistance to unpredictable disturbances
- demonstrates that an apparaently "open-loop," "ballistic" behavior is based on closed-loop kinesthetic control of limb positions and movements

[edit]

Same disturbance, same action, different "stimulus": Cziko adaptation of Marken (1992, pp. 61-66) demonstration

In Rick Marken's *Mind Readings* collection, he shows the result of a computer program that involves a tracking task. The same pattern of disturbance is used for two trials. Because the subject's actions must compensate for the disturbance in order to do the tracking task, there is a high correlation between the subjects behavior across the two tasks. However, there is a low correlation across the two tasks between what the subject sees. Using an open-loop, input -> output, stimulus -> response view of behavior, it is impossible to account for the fact that the subject creates the same pattern of behavior across the two trials while the pattern of the stimulus is very different across the two trials.
This demonstration can be simulated using three pencils or other writing instruments (e.g., felt markers) attached to each other with rubber bands, like this . . .
|---|---| |---|---| |---|---|
. . . where each group of three vertical lines represents one writing instrument and the broken horizontal lines represent rubber bands connecting them.
The experimenter (demonstrator) holds the bottom writing instrument and the subject the top one so that the middle writing instrument is located on a horizontal line written on the writing surface. The task of the subject is to keep the middle writing instrument on this line while keeping his or her writing instrument directly above that of the disturber as the latter moves his or her writing instrument from left to right as well as up and down.
The result will be three traces on the writing instrument. The top is a record of the subjects behavior (actions), the bottom is a record of the disturbance, and the middle one is a record of the controlled variable ("stimulus"). The top and bottom traces will be mirror images of each other, while the middle trace will appear to be a line that appears to wander randomly around the target line (better control will result in less wandering).
The task is then repeated (perhaps with writing instruments that leave a different color) with the experimenter (disturber) retracing the original disturbance. The subject's actions should then be very similar to the original actions with the two traces being quite close to each other. However, it will be easily seen that there is no correlation between the controlled

variable ("stimulus") across the two trials.
There is no way to explain this phenomenon (different "stimuli" causing similar behavior) using a one-way, input-output, stimulus-response view of behavior. It is, however, easily explained and modelled using PCT.
[edit]

Why you need to know the controlled variable to predict behavior (Cziko)

The "behavioral illusion" (who first used this term) refers to the fact that it often appears that behavior is a response to a stimulus instead of the control of a perception. For example, a person driving a car west on a straight road is seen to turn the steering wheel to the right each time a gust of wind comes from the north. So it appears as if the wind (stimulus) causes the driver to turn the steering wheel to the right (response). But anyone with knowledge of PCT will know instead that the wind is instead a disturbance to the driver's controlled variable of seeing the car stay in the center of the driving lane and the driver moves the steering wheel to the right in order to control this perception (and not be blown into the lane to the left).
One might argue that if psychology is concerned with predicting behavior, knowledge of the disturbance is good enough for prediction, i.e., if we know that if there is a gust of wind from the north, we can successfully predict that the driver will turn the steering wheel to the right. So why bother with figuring out what the controlled variable is?
This demonstration shows why discovering the controlled variable is essential to predicting behavior. It uses the standard to knotted rubber bands, but with the addition to a length of string tied to the side of the rubber band that is held by the disturber.
The subject is asked to keep the knot over a visible point on the wall or board. It can easily be seen that if the disturber pulls his end of the knotted rubber bands ot the left, the subject will compensate by pulling to the right. If the disturber moves his or her end up, the subject will move his or her end down, etc. So we are able to predict the subject's behavior by simply noting the disturbance (the position of the disturber's hand) and conceptualizing the subject's behavior (movement of his or her hand) as a response to a stimulus.
However, the disturber can now keep his or her hand that was previously pulling on the rubber band motionless while the other hand is used to pull on the string connected to the rubber band. Now it will be seen that even though the distruber's originally disturbing hand is motionless, the subject nonetheless acts to keep the know on the desired spot. Or the disturber can loosen the grip of the originally disturbing hand on the rubber band and move it back and forth along the rubber band (held immobile by the string held in the other hand). Now it will be seen that even though the originally disturbing hand is moving, the subject will not move his or her hand.
So, in order to predict one's behavior, one needs to understand what the subject's controlled variable is since there may be more than one way to disturb this variable, or something that once was a disturbance may no longer be acting on the controlled variable. The Test for the Controlled Variable is necessary to do this. The behavioral illusion may lead one to believe that one's behavior is understood and predictable, but this is only an illusion.
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Levels of perceptual control

- See Robertson and Powers (1990, pp. 21-22) for first-, second-, third- and fourth-order control (to be summarized hear)

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Writing

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Writing with eyes open vs. eyes closed (Cziko)

- demonstrates difference between visual and kinesthetic feedback
    - difficulty of dotting i's and crossing t's and write on lined paper without visual feedback

[edit]

Writing with non-dominant hand (Cziko)

- normal writing
    - is difficult because one knows what the writing should look like, but doesn't know ow hand should feel (kinesthetic reference levels) to make it look that way
- mirror-image writing (as practiced by Da Vinci)
    - is initially difficult since don't know what writing should look like nor how it should feel
    - much easier if person writes normally with dominant hand simultaneously; person can then imagine dominant hand writing and write reversesd with non-dominant hand
    - may be easier with eyes closed
    - would be interesting to try in Chinese and other non-Roman writing systems

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Speech

- talk with tip of tongue held against upper (hard) or lower (easier) teeth (Cziko)
    - notice how sound /t/ is made
    - ability to speak comprehensibly with tongue in abnormal position shows that speech sounds are not pre-programmed motor outputs
    - same phenomenon demonstrated when talking with cigarette, eating utensile or other object in the mouth (e.g.., food)

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Eye pushing

- with one eye closed, push outside corner of open eye with finger and attempt to stand or walk (or ride a bicycle) in a straight line (Cziko)
- person will probably attempt to keep body perpendicular to the apparent (distorted) horizon resulting in leaning or walking in an undesired curved path
- demonstrates that use of visual feedback for standing, walking, etc. which is difficult to ignore (with practice, one may pay more attention to proprioceptive and kinesthetic feedback, making the task eaiser)
- blind people can stand, walk and run; an they ride a bicycle?
- is visual feedback easier to ignore for standing than for walking?

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Learning to ride a bicycle: Constraining reorganization (Cziko)

The principal controlled perceptual variable in learning to ride a bicycle is being able to move the bicycle by pedalling while remaining upright on two wheels without falling over. This is usually learned by children via trial and error (reorganization in PCT terms), often with the aid of training wheels (also called "stabilizers").

The principal difficulty with learning to ride a bicycle is that the way we have learned to restore balance while sitting, standing or walking does not work for bicycle riding. While sitting, standing or walking, if you feel yourself falling to the left, you attempt to shift your body weight to the right to restore balance. But on a bicycle, this natural tendency often leads one to turn the handlebars to the right when the bicycle rider finds him- or herself falling to the left. This action does not restore balance; rather it accelerates the loss of balance as turning the front wheel to the right creates centrifugal force which pushes the bicyclist to the left.

Instead, the beginning bicyclist needs to learn to turn the front wheel in the direction of the fall to restore balance. Explaining this to the bicyclist and allowing him to practice this while the bicycle is held and tilted by the teacher should greatly facilitate learning to ride a bicycle.

Or course, there is no way to tell the learner exactly how much to turn the handlebars to restore balance, so some element of trial and error must remain in the reorganization of perceptual control systems needed to learn to ride a bicycle. But explaining the basic principles of bicycle and balance (that is, turning the handlebars in the direction of the fall) should facilitate and accelerate the process. This is apparently the method used by Pedal Magic (although I have not yet seen this bicycle teaching video).

In addition to maintaining balance while riding straight, a bicyclist must also learn how to make turns. If you ask someone who knows how to ride a bicycle how to turn, he or she will most likely tell you that you simple turn the handlebars in the direction you want to go. This is not quite right, however. If you are riding in a straight line and want to turn toward the RIGHT, turning the handlebars to the right will cause the bicycle to lean to the left and the bicyclist will then have to learn the handlebars to the left to restore balance, in effect accomplishing a LEFT turn. So, in order to turn the RIGHT, the bicyclists must first turn the handlebars slightly to the LEFT, and then to the RIGHT after the bicycle has begun to lean to the right. This initial turn of the handlebars in the direction opposite to the desired direction of a turn is referred to as counter-steering.

Counter-steering on a bicycle is so subtle and slight given the low weight and low speed of most bicycling so most bicyclists are not even aware that they do it. The necessity of counter-steering, however, becomes clear if the bicyclist is riding at the very edge of a roadway (say to the right) and he or she wants to move left away from the edge. If there is no room for the bicyclist to first counter-steer to the right, the bicyclist will be unable to move left away from the edge of the roadway. One gets the feeling that one is "glued" to the edge of the roadway with no way to move away from it because there is no room to first counter-steer toward the edge to be able to turn away from it.

The much greater weight and increased speeds of motorcycles, however, makes counter-steering much more pronounced and essential to safe motorcycling handling technique (see [http://en.wikipedia.org/wiki/Counter-steering#Motorcycles].

Counter-steering is not used on vehicles having more than two fore-and-aft wheels.

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Games

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Coin game (see Powers, 1973, pp. 235-236)

- demonstates:
  - difficulty of finding controlled variable

  - different verbal descriptions for same perception

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Trippples (by Powers)

Out of production. But see [1] and/or search for "Trippples" on Google. May be found for sale on eBay.

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Rubber band, puck and marble board game

from Powers, CSGnet 1992.03.23 20:00

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Electronic-mechanical devices

- Line Tracker Robot formerly available from Edmund Scientific Co. (# E34,355; $49.95)
  - robot follows black line on light background using infrared sources and detectors and controlling for minimal reflected infrared radiation
  - is successful in following line despite using primitive "bang-bang" control systems (motor driving one wheel is on when infrared detected, off when not)
- Model airplane servo-mechanism with transmitter (available from hobby shops)
  - servo gear can be easily rotated with power off
  - very hard to move with power on (it now has a reference level and will resist disturbances)
  - servo can be felt to resist disturbances
  - transmitter varies reference signal
  - demonstrates advantages of manipulating reference level and letting lower-level control system take care of compensating for disturbances (tells lower system what to perceive, not what to do)
- Newton's Folly formerly available from Edmund Scientific Co. (# E36,216; $119.00)
  - metal ball suspended in air using stepped magnetic fields and infrared feedback
  - drammatically demonstrates how active control can achieve stability in a far-from-equilibriuim situation

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Computer-based demonstrations

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Powers

See Bill Powers' Home Page

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Marken

See Rick Marken's On-Line Control Demos

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References

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- Marken, R. S. (1992). *Mind readings: Experimental studies of purpose*. Chapel Hill, NC: New View Publications.
- Robertson, R. J., & Powers, W. T. (Eds.) (1990). *Introduction to modern psychology: A control-theory view*. Gravel Switch, KY: The Control Systems Group.
- Powers, W. T. (1973). *Behavior: The control of perception*. Hawthorne, NY: Aldine/De Gruyter.

Date: Tue Jul 21, 1992 10:03 am PST Subject: Portable Demos [from Gary Cziko 920721.1215] For the Durango meeting next week, I am compiling a list of portable demonstrations of perceptual control and will demonstrate a few of my own. I think I have already included most of the demos mentioned in the net plus the classic ones, but I fear I may have missed a few, particularly ones involving cooperation-conflict in social situations. If you have a portable demo that you don't think I know about, please clue me in. I know that Clark McPhail uses some demos involving BIG rubber bands in his sociology class, but I don't know exactly how this work. I will eventually compile all of these and make them available on the fileserver. --Gary